PATENT SPECIFICATION

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Apparatus for the Continuous Gelatinisation of Starch and Starch Derivatives

We, ESCHER WYSS G.m.b.H., a German Body Corporate, of Ravensburg, Wurttemberg, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described, in and by the following statement.

This invention relates to apparatus for the continuous gelatinisation of starch.

Starch is an important basic material and auxiliary material for numerous branches of industry. It is used in the papermaking industry for sizing the paper in the pulp and on the surface, and as a binder for coating mixtures. It is also used in the textile industry for sizing and dressing, and is employed in numerous branches of the foodstuffs industry as a thickener. Still further, it is employed in the fermentation industry and in brewing for fermentation processes, and is used for the manufacture of dextrin, starch syrup and glucose. A prerequisite for the use of starch in the above-mentioned processes is complete gelatinisation. By the action of a temperature in the region of 65° to 70° C. and determined by the nature of the starch, the starch grains are caused to swell and are finally destroyed. The amylopectin and amylose molecules, which build up the starch grain, can hydrate and form a thick paste. The higher the concentration of this starch paste, the higher is also the viscosity of this paste, unless the amylopectin and/or amylose molecules have been exposed to a mechanical, chemical or enzymatic breakdown before or during gelatinisation.

Thermal gelatinisation of starch may also be replaced entirely or partly by alkaline gelatinisation. For this purpose, an ungelatinised or partly gelatinised starch suspension is mixed with an alkaline solution of chemicals, preferably alkali lyes.

Starch paste can be made in tanks by a batch process. Either a starch suspension is raised to the gelatinising temperature by direct or indirect heating, or a starch suspension is poured into hot or heated water with stirring, or starch is sprinkled into hot or heated water with stirring. The disadvantages of these processes are that large tank installations are required for making the pastes, the installations require scrupulous attention, the starch gelatinisation in the batch process can only be inadequately adapted to sudden disturbances and changes in operation, the necessary uniformity of the pastes cannot be adequately ensured in every batch, and the starch pastes produced in a large quantity in each batch have to be kept during consumption for a long time at elevated temperatures, often in a temperature range which is advantageous for enzyme action, so that a reduction in yield and quality may ensue. In the manufacture of starch paste by the batch process, the workable starch concentration is limited to from 0 to 12%, unless pretreated, so that decomposed starches of relatively low specific viscosity are used. Attempts have often been made to obviate the difficulties in batch production of pastes by ordering for the required purposes a starch gelatinised and dried on hot rolls or by means of some other process and using this so-called swelling starch. Transport of undried starch pastes between different works is accompanied by considerable risk, since as already mentioned starch pastes are exceptionally prone to enzymatic breakdown reactions. The transport of the amount of water contained in the starch pastes over considerable distances is in any event to be regarded as uneconomical. The use of swelling starch

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is much more expensive than the use of a freshly prepared starch paste, since drying of the swelling starch is an essential additional part of the process. For the many applications of starch, therefore, a method for the rational, continous gelatinisation of starch directly before use is of exceptional interest.

The present invention accordingly relates to apparatus for the continuous gelatinisation of starch, partly decomposed starch or starch derivatives by means of a gelatinising reagent such as steam or a chemical solution. This apparatus, in accordance with the invention comprises a tube having one or more constrictions through which is passed a suspension of of the substances to be gelatinised, and in the wall of which, after the constriction, in the transitional region to the full cross-section one or more inlet orifices are provided for said gelatinising reagent.

It has been found that, with such an extremely simple and reliable apparatus, it is possible to produce completely homogeneous starch pastes from untreated native starch in the concentration range 0 to 16% if heating steam is introduced directly into the suspension through the aforesaid inlet orifices in the tube wall. The same apparatus may also be used, however, if instead of heating steam, a chemical solution producing gelatinisation is introduced through the said orifices.

The constriction in the tube may be for example a diaphragm with one or more passages or a nozzle. Furthermore, the constriction may be followed by a steady widening of the tube cross-section. Two or more constrictions may also be provided one after the other in the direction of flow.

In this apparatus, the starch suspension and starch paste moves continuously through the reaction zone along a pressure gradient. On passing through the constriction, and on the mixing of the starch milk with the steam or chemical solution, the compressive and shearing forces exerted on the starch paste are such that paste formation is advantageously assisted.

The apparatus may also be used for the processing of starches which have been pretreated chemically, enzymatically or mechanically for increasing or reducing the viscosity of the pastes and hence for increasing or reducing the workable starch concentration. Furthermore, the apparatus may be used for the continuous gelatinisation of starch derivatives, such as starch ethers, starch phosphates, oxidation products of starch, or starches partly decomposed by acids or enzymes.

Since starch gelatinisation gencraly has to be carried out in a temperature range from 50°C. to 100°C., while the starch pastes are used in a different temperature range (which in most cases is lower), it is advantageous for the continuously produced starch pastes to be cooled continuously. For this purpose, the apparatus according to the invention can be extended by the provision, after the inlet orifice or orifices for the steam or the gelatinising chemical solution, of at least further constriction which is followed by orifices in the tube wall for the supply of cooling and diluting liquid. Through these last-mentioned orifices it is also possible to introduce if desired a liquid for preserving the paste.

In a preferred form of the apparatus there is furthermore provided, in the direction of flow of the suspension or paste, after the inlet orifice or orifices for the steam or chemical solution, a screen for the temporary subdivision of the substance into a number of partial streams. This step assists the formation of a homogeneous paste and also serves to suppress or limit the build-up of structure viscosity in the starch paste on its passage through the apparatus.

It may also be desirable for the paste formed to remain for some time in the apparatus. For this purpose, the apparatus according to the invention may be extended by providing, after the inlet orifice or orifices for the steam or for the gelatinising chemical solution or for the supply of cooling, diluting or preserving liquid, at least one further constriction followed by orifices in the tube wall for the return of the already produced starch paste to a point situated upstream — for example, to a point in the apparatus situated immediately after the commencement of paste formation.

Figures 1 to 8 of the accompanying drawings show sectional views through a number of different constructional examples in accordance with the invention.

In all the illustrated examples, the starch suspension to be gelatinised is passed through a tube 1 in the direction of the arrow. This tube is surrounded by a jacket 2 which, with the tube 1, confines a space 3 for a gelatinising reagent such as steam.

According to Figure 1, a diaphragm 4 is inserted in the tube 1 as a cross-section constriction. Following this diaphragm, that is to say, in the transition region, in which the flowing medium is again distributed over the full cross-section of the tube, peripherally and longitudinally distributed holes 5 are provided in the tube wall 1 and serve as inlet orifices for the steam necessary for gelatinisation.

According to Figure 2, two cross-section constrictions 4 in the form of diaphragms follow one another in the direction of flow. Following the first constriction are inlet

orifices for the steam, these orifices being in the form of passages 6 inclined to the tube axis in the direction of flow of the suspension. After the second constriction there are steam inlet orifices 7 in the tube wall as in the case of Figure 1, and after these orifices is a screen 8 which subdivides the suspension temporarily into a number of partial streams.

In the embodiment according to Figure 3, a diaphragm-like constriction 9 is followed by a gradual widening 10 of the tube cross-section. The steam inlet orifices are provided in the region of this widened portion 10 as passages 11 inclined to the tube axis in the direction of flow of the suspension.

In contrast to the arrangements shown in Figures 1 to 3, which have sudden cross-section constrictions, the apparatus according to Figure 4 has a slightly conical cross-section constriction 12, which may preferably also be of nozzle-like construction, followed by a gradual widening 13. In this case, the steam inlet orifices are in the form of passages 14 perpendicular to the tube axis. The widening 13 is followed by a second cross-section constriction in the form of a diaphragm 15, and the steam inlet orifices following this diaphragm are in the form of passages 16 inclined to the tube axis opposite to the direction of flow of the suspension.

Instead of individual holes or passages 5, 6, 7, 11, 14, 16 an annular gap or a series of annular gaps could possibly be provided.

In the apparatus described in Figures 1 to 4, clear functional relationships exist between the quantity and temperature of the starch suspension to be gelatinised, the starch content thereof and the nature of the starch, the quantity, the temperature and the initial pressure of the gelatinising reagent (heating steam or chemical solution), the free cross-sectional area for the passage of the starch suspension and of the gelatinising reagent, and also the velocities thereof. With constant free cross-sectional areas for the conveying and mixing of starch suspension and gelatinising reagent, the gelatinisable starch concentration is primarily determined by the admission pressure of the gelatinising reagent. With constant input pressure of the gelatinising reagent and a fixed free cross-sectional area for the passage thereof through the orifices in the tube wall, specific properties of the product (gelatinisation temperature, condition of swelling and disintegration of the starch) are only obtained with a specific, constant throughflow quantity of the product. However, if it should happen that, after a lowering of the production capacity, the flow velocity of the starch suspension through the constriction in cross-section and the subsequent tube section of the gelatinising apparatus falls below a predetermined ratio with respect to the input velocity of the gelatinising reagent with a constant input pressure, the components will not be uniformly mixed. If the flow velocity of the starch suspension increases after a rise in the processing capacity, a correspondingly larger amount of gelatinising reagent has to be introduced in order to maintain the desired properties of the starch product. With constant input pressure of the gelatinising reagent, the free throughflow area must be modified in order to ensure the necessary transfer of substance or heat.

The embodiments shown in Figures 5 to 8 of the drawings provide the possibility of adapting the apparatus to different working conditions by providing means which permit variations in the relative quantities, pressures and velocities of the suspension of the substance to be gelatinised and of the gelatinising reagent.

In all these constructional forms, the starch suspension to be gelatinised is conducted in the direction of the arrow through the tube 1. The said tube is enclosed by a jacket 2 which, in conjunction with the tube 1, defines the space 3 for the gelatinising reagent which is to be supplied, more especially steam or a solution of chemicals. The tube 1 has a conical constriction 17 in cross-section and a subsequent steady enlargement 18 for the cross-section, having inlet orifices 19 for the gelatinising reagent.

According to Figure 5, for varying the free cross-sectional area of the inlet orifices 19, a closed sleeve 20 serving as a covering member is arranged co-axially of the tube 1, the position of the tube being adapted to be changed in relation to the orifices 19. With axial displacement of the sleeve 20, the number of the free orifices 19 for the gelatinising reagent is modified. In order to render such a displacement possible, sleeve 20 is provided on its underside with a rack 21, with which meshes a gearwheel 22 adapted to be actuated from outside by means (not shown).

According to Figure 6, a sleeve 20^1 is provided as cover member, said sleeve comprising orifices 19^1 corresponding to the inlet orifices 19 for the gelatinising reagent. With displacement or rotation of the sleeve 20^1, the free cross-sectional area of the individual inlet orifices 19, 19^1 is altered without the number of the free flow orifices being reduced or increased. The sleeve 20^1 can be externally actuated by a rod 23.

With the arrangement according to Figure 7, a displacement rod 24 is provided co-axially of the tube for the purpose of

altering the free cross-sectional area for the suspension in the transition region 18 following the constriction 17 in the cross-section of the tube 1, the rod being of a form so that it tapers towards the narrowest cross-section of the tube 1. The rod 24 can be moved axially from outside, its pointed end finally extending into the smallest cross-section of the tube 1.

According to Figure 8, the solid displacement rod 24 is replaced by a hollow displacement rod 24^1 for accommodating the gelatinising reagent, the said rod 24^1 comprising outlet openings 25 facing the flowing suspension of substance. The openings 26 produce a connection between the jacket chamber 3 and the interior of the displacement rod 24^1. The interior of the rod 24^1 could however also be charged with gelatinising reagent independently of the jacket chamber 3.

Each of the means illustrated in Figures 7 and 8 can also be employed jointly with the means illustrated in Figures 5 and 6. The arrangements which have been described enable the flow conditions in the interior thereof to be substantially adapted to the operating conditions prevailing at the time. The cover members 20, 20^1 of Figures 5 and 6 particularly influence the supply of the gelatinising reagent, whereas the displacement rods 24 and 24^1 of Figures 7 and 8, respectively, permit the velocity of the suspension in the constricted portion of the cross-section to be altered. These means can be operated manually or also by an automatic regulating device. For example, a meter element 27 for the gelatinisation temperature or for the throughflow quantity of suspension is provided in Figure 5, the said element acting on the gearwheel 22 actuating the sleeve 20, so that with rising temperature, the sleeve 20 is adjusted in the direction for reducing the supply of steam through the orifices 19, and with an increase in the throughput quantity of suspension, it is adjusted in the direction for increasing the supply of steam or another reagent through the orifices 19. A regulating means with a corresponding meter element 27^1 according to Figure 7 on the contrary, would have to act on the displacement rod 24 in the sense that, with a decrease in the throughput quantity of suspension or, increase of temperature the free cross-sectional area is reduced by axial displacement towards the constriction in cross-section, thereby increasing the flow velocity of the said suspension, in order to guarantee a uniform mixing of suspension and gelatinising reagent.

The fitting of displacement members obviates the otherwise necessary interchange of nozzles and effective tube path of the gelatinisation arrangement with changing production capacity.

In order to exert an additional advantageous effect on the substance to be treated, those surfaces of the arrangement coming into contact with the suspension of substance and the paste, including a displacement rod if it is provided, can be formed with irregularities. These may for example comprise annular or helical recesses, such as screwthreads of suitable depth and pitch, or also of separate protuberances, such as pins or hooks. The boundary layer of the flowing substance is influenced by these measures and an additional mixing effect is produced.

The apparatus described may be constructed as a component part of a paste-using machine or plant, for example a paper-making machine, a sizing plant or fermentation plant, thereby obviating long distances for the transport of the paste to the place of use.

Without departing from the principal of the invention, the different embodiments of the cross-section constriction and the transition region as illustrated by the parts 4 of Figures 1 and 2, 9 and 10 of Figure 3, 12 and 13 of Figure 4 and 17 and 18 of Figures 5 to 8 may be interchanged.

WHAT WE CLAIM IS:—

1. Apparatus for the continuous gelatinisation of starch, partly decomposed starch or starch derivatives by means of steam or a chemical solution, comprising a tube having one or more constrictions through which a suspension of the substances to be gelatinised is led, and in the walls of which, beyond the constriction in the transition region to the full cross-section, there are one or more inlet orifices for the steam or chemical solution.

2. Apparatus acording to Claim 1, in which the constriction consists of a diaphragm with one or more passage orifices.

3. Apparatus according to Claim 1, in which the cross-section constriction consists of a nozzle.

4. Apparatus according to any one of Claims 1-3, in which the constriction is followed by a gradual widening of the tube cross-section.

5. Apparatus according to any one of Claims 1-4, in which two or more constrictions are provided one after the other in the direction of flow.

6. Apparatus according to any preceding claim, in which peripherally distributed holes are provided in the tube wall for the introduction of steam or chemical solution into a suspension of substance to be gelatinised.

7. Apparatus according to any one of Claims 1-5, in which an annular gap is provided in the tube wall for the introduction of steam or chemical solution into the sus-

pension of substance to be gelatinised.

8. Apparatus according to any one of Claims 1-5, in which the inlet orifices for the steam or chemical solution consist of passages which converge towards the tube axis in the direction of flow of the suspension of substance.

9. Apparatus according to any preceding claim, in which a screen for the temporary subdivision of the substance into a number of partial streams is provided in the direction of flow of the suspension of substance or paste after the inlet orifice or orifices for the steam or chemical solution.

10. Apparatus according to Claim 1, in which after the inlet orifice or orifices for the steam or chemical solution, there is provided at least a further constriction followed by orifices in the tube wall for the supply of cooling and diluting and/or preserving liquid.

11. Apparatus according to Claim 1 or Claim 10, in which after the inlet orifice or orifices for the steam or chemical solution, there is provided at least one further cross-section constriction with adjoining orifices in the tube wall for the return of already produced paste to a point of the apparatus situated upstream for the purpose of increasing the length of stay of the starch paste in the apparatus.

12. Apparatus according to any preceding claim, in which means are provided which enable the relative quantities, pressures and velocities of the suspension of substances to be gelatinised and of the gelatinising reagent to be altered.

13. Apparatus according to Claim 12, in which the free cross-sectional area of the inlet orifice or orifices for the gelatinising reagent is adapted to be altered.

14. Apparatus according to Claim 13, in which a cover member is provided, the position of which relatively to the inlet orifice or orifices is adapted to be altered.

15. Apparatus according to Claim 14, in which the cover member is formed as a closed sleeve which is arranged co-axially of the tube and which, by axial displacement, alters the number of the free orifices for the gelatinising reagent.

16. Apparatus according to Claim 14, in which the cover member consists of a sleeeve which is arranged co-axially of the tube and which comprises orifices corresponding to the inlet orifices for the gelatinising reagent and alters the free cross-sectional area of the individual inlet orifices when it is diplaced or rotated.

17. Apparatus according to Claim 14, in which control or regulating means are provided which alter the position of the cover member as a function of the gelatinisation temperature or the throughflow quantity of the starch product.

18. Apparatus according to Claim 12, in which the free cross-sectional area for the suspension in the transition range following the constriction in the cross-section of the tube is adapted to be altered.

19. Apparatus according to Claim 18 in which a displacement rod is arranged co-axially of the tube for altering the cross-sectional area.

20. Apparatus according to Claim 19, in which the displacement rod is displaceable axially.

21. Apparatus according to Claim 20, in which the displacement rod has a form which tapers towards the narrowest cross-section of the tube.

22. Apparatus according to Claim 20, in which the displacement rod is hollow for accommodating the gelatinising reagent and comprises outlet openings towards the flowing suspension.

23. Apparatus according to Claim 20, in which control or regulating means is provided which alter the position of the displacement rod as a function of the gelatinisation temperature or the throughflow quantity of the starch product.

24. Apparatus acording to Claim 12, in which those surfaces which come into contact with the suspension and the paste are provided with irregularities.

25. Apparatus according to Claim 24, in which the irregularities consist of annular or helical recesses.

26. Apparatus according to Claim 24, in which the irregularities consist of individual protuberances.

27. Apparatus according to any preceding claim, in which it forms a component part of a paste-using machine or plant.

28. Apparatus for the continuous gelatinisation of starch, partly decomposed starch or starch derivatives by means of steam or a chemical solution, substantially as described with reference to any one of Figures 1-8, of the accompanying drawings.

For the Applicants:
LLOYD WISE, BOULY & HAIG,
Chartered Patent Agents,
10, New Court,
Lincoln's Inn,
London, W.C.2.

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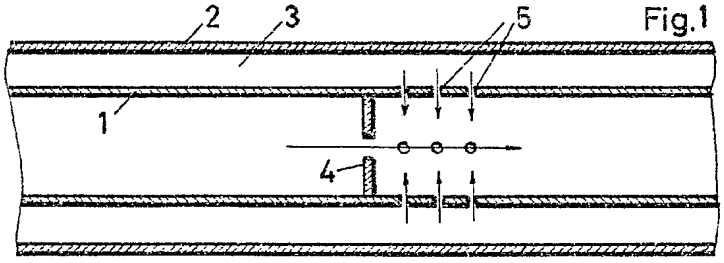

Fig.1

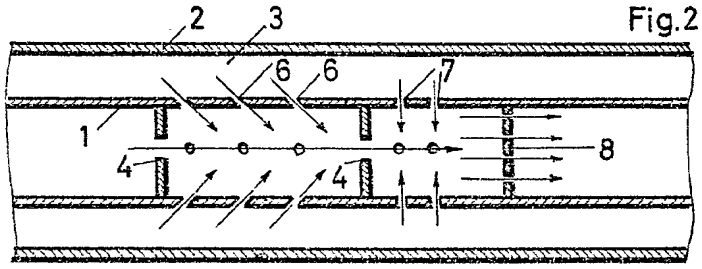

Fig.2

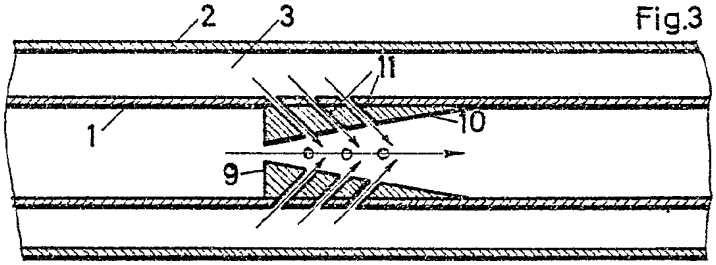

Fig.3

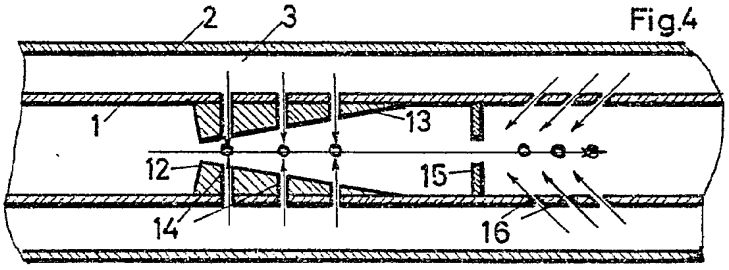

Fig.4

995,660 COMPLETE SPECIFICATION
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SHEETS 1 & 2

Fig.1

Fig.2

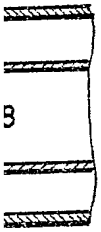
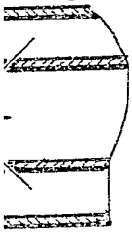


Fig.3

Fig.4



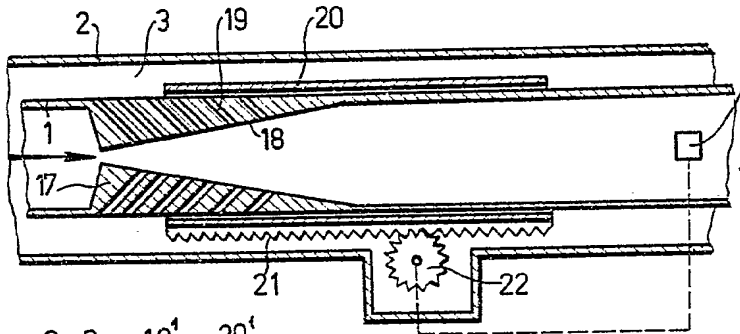


Fig.5

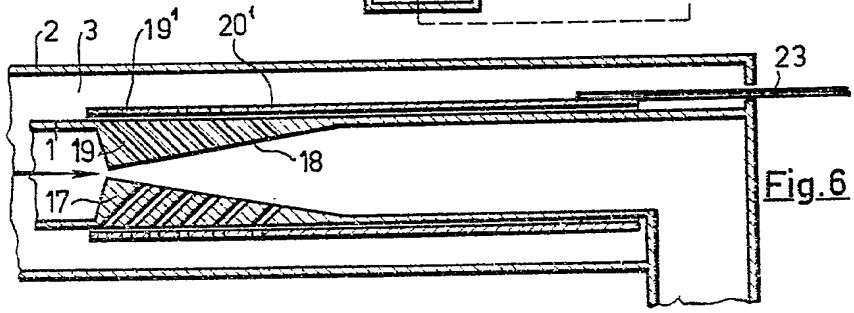


Fig.6

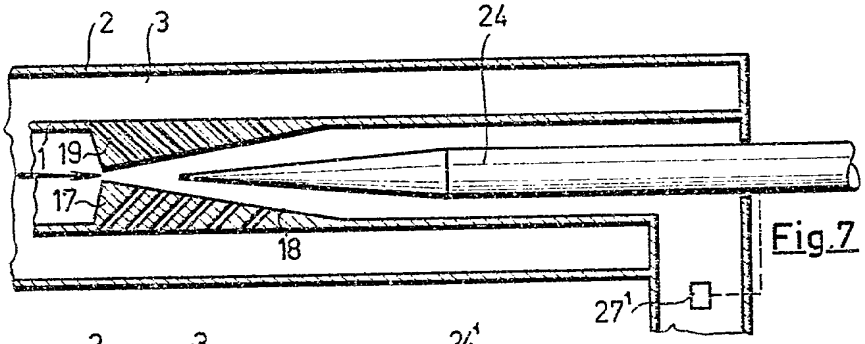


Fig.7

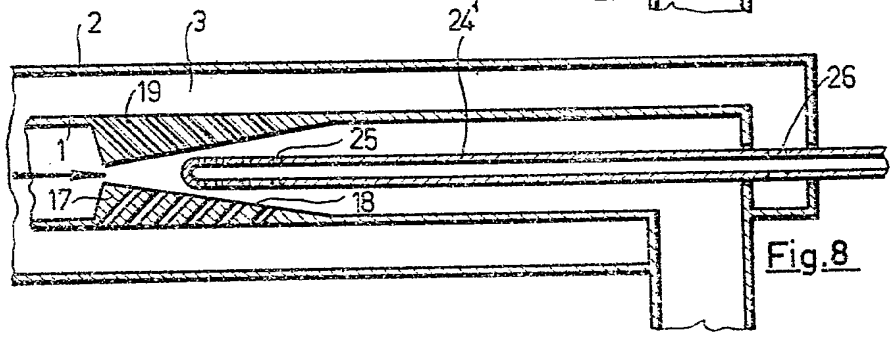


Fig.8

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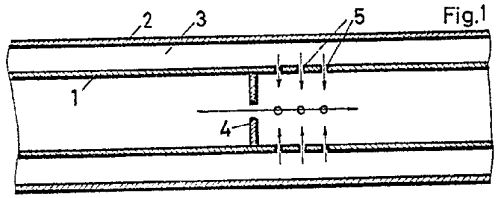

Fig.1

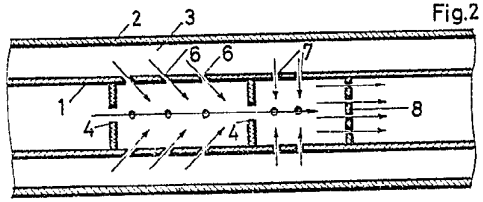

Fig.2

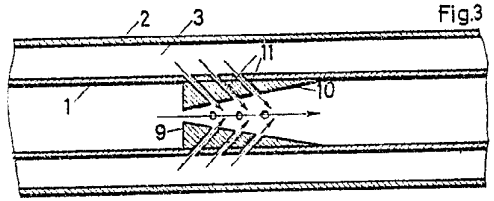

Fig.3

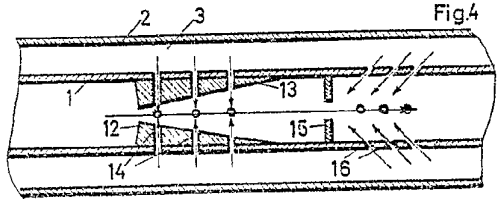

Fig.4

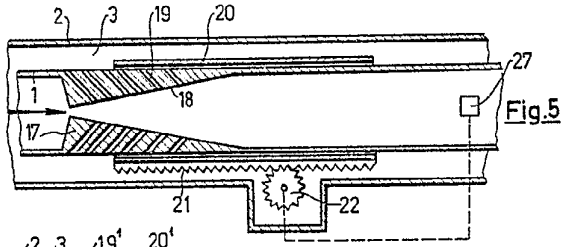

Fig.5

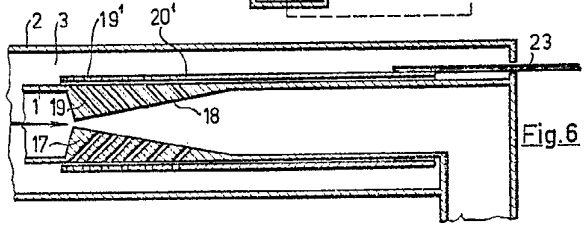

Fig.6

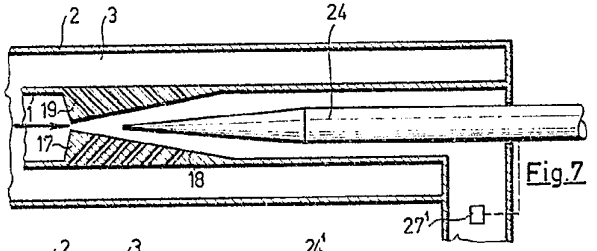

Fig.7

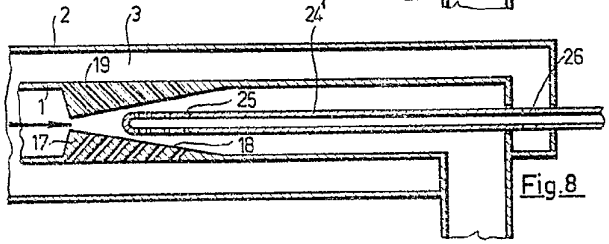

Fig.8